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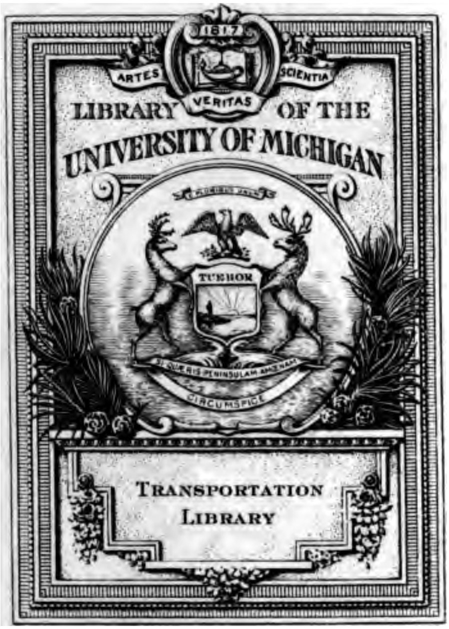

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THE
FIREMAN'S GUIDE.

A HANDBOOK
ON
THE CARE OF BOILERS,

BY TEKNOLOGFÖRENINGEN T. I., STOCKHOLM.

Translated from the Third Edition,
and Revised by

KARL P. DAHLSTROM, M. E.

Twelfth Edition

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PREFACE

Having noticed that boiler explosions too frequently occur through neglect or incompetency of the attendant, the translator has, with a view to lessen the number of such occurrences, placed this little book before the public ; and he trusts that firemen, engineers and even boiler-owners may find in it much that may be of service to them.

The book was originally written and published in Sweden by a society of experienced engineers (Teknologföreningen T. I., Stockholm) urging that the best way to prevent accident and afford a saving of fuel was to give strict regulations as to how a boiler should be fired and managed. It was favorably received by the public and has passed through several editions.

The book is in two parts, *the first of which* contains, more extensively, rules and directions for the general care of boilers ; *the second* a summary of regulations.

It has been the aim of the translator through this work to use only such words and phrases as shall be readily understood by all classes for whom it is written.

I desire to return my best thanks to Messrs. J. E. Greensmith and T. M. North for much valuable assistance rendered in the translation and revision of this work.

KARL P. DAHLSTROM, M.E.

MASON MACHINE WORKS, TAUNTON. MASS.

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THE FIREMAN'S GUIDE.

INTRODUCTION.

THE proper management of a boiler is of just as much importance as its proper construction, as it is liable to get out of order and become dangerous. Besides, it is necessary, in case of danger, to know what precautions should be taken to prevent accidents and save life and property.

The fireman's duties are thus of far more importance and claim far more knowledge than is generally understood, and his responsibilities are great. To attend to his business in a proper manner, he should know his duties exactly and be reliable, sober, and careful. The safety of himself and fellow-workmen and the durability of the tools and appliances in his care depending on his doing his duties very faithfully, he should always do his best to keep his boiler in good condition and make himself familiar with its properties.

It can be learned *only by experience* how to fire in the best and most economical manner with different kinds of fuel, and what is said here in this matter is therefore to be regarded only as a direction.

As to the management of the boiler, it is of the greatest importance for the fireman to obtain necessary instruction, as faults and neglect that to people of inexperience seem to be of little note may often cause the most disastrous results. It is necessary that the fireman should pay strict attention to what there is to learn in this matter, and the following rules are a compendium of the principles every boiler-owner and fireman should thoroughly know, and the action that should be taken in regard to the safe management of boilers.

CHAPTER I.

FIRING AND ECONOMY OF FUEL.

Precautions before Starting the Fire.

Before starting the fire the fireman should see:

1. That there is sufficient water in the boiler;
2. That the furnace* and flues are clean, and
3. That the grate-bars are in their right places;
4. That there is nothing left in the furnace or flues (in case of repair having been made), and
5. That the upper gauge-cock is open to let out the air from the boiler, while steam is forming.
6. When the boiler is fed by hand-pump, he should see that this is in a good condition.
7. That dampers and doors move easily, and
8. That all other parts of the boiler are in complete order.

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* In order to gain more simplicity of language, the word "furnace" is used through this work instead of the more correct "furnace or fire-box."

He must not rely on the supposition that the water, he has previously put in, is still in the boiler, as it may have run out, without his knowledge, through a leak or any open cock. He can neither be sure that the glass gauge shows the true water-mark, until he has examined it. This is done in the following manner: shut off the lower gauge-cock and empty the glass by the lower glass-cock; then shut the glass-cock and open the gauge-cock; if everything is all right, the water will now rise in the glass to the same height as before.

After Starting the Fire.

After starting the fire, and the steam-pressure having begun to rise, he should see:

1. That all the joints and packings are tight, and
2. That all the cocks and valves move easily.

The Care of the Fire.

The fire must not be hurried too much, but should be left to gain its full strength slowly. This is done easiest by putting in *only a small quantity of fuel at a time.* By proceeding in this way, a nicer fire will be obtained in a shorter time than by heaping too much fuel, as this chokes the fire instead of increasing its force, thus causing a loss of time and fuel.

Proper Firing.

It is fired properly when the fuel is consumed in the best possible way, no more being burned than what is needed for producing a sufficient quantity of steam and keeping the steam pressure even. For this purpose, there must be a complete combustion in the furnace, and it is going on when the fuel is burning with *a bright flame, equally all over the grate.*

A blue flame, dark spots, and smoke show that the combustion is not complete, and should be carefully prevented. When the incomplete combustion is due to want of air, it can be overcome by increasing the draft.

Regulating the Draft.

In order to make a complete combustion possible, the draft must be so regulated as to get just *the right quantity of air* into the furnace, neither too much nor too little. The dampers and doors should therefore be managed with very much judgment. If possible, the doors should be so arranged as to facilitate the regulating of the air-holes.

After every firing, a small quantity of air should be let in over the grate through the regulating holes, or by keeping the furnace door a little while ajar.

Smoke from the Chimney.

Dark and heavy smoke from the chimney shows incomplete combustion and should be avoided, as *a waste of fuel* takes place. Most kinds of coal, however, immediately after firing give more or less smoke, that cannot be prevented.

The Progress of Firing.

It should be fired equally and regularly. The fuel should be put in frequently, each time only so much as is needed to maintain a bright fire. More than necessary being thrown in, the fire is cooled off and the circulation of air is hindered; if too little be put in, the fire cannot be kept up satisfactorily, as it soon grows so thin that more air passes through the grate than is advantageous for a complete combustion.

The Fuel on the Grate.

The grate must always be kept *well covered* with a fire *of equal thickness.* Bare spots must never be allowed, but should be covered over directly they appear, as cold air passes through in these places.

The thickness of the fire is to be in accordance with the quality and size of the fuel, in order to let through the proper quantity of air.

You should never put in coals of larger size than your fist. *The coal* being "hard," the fire should be as thin as possible, from three to six inches deep: when "soft" coal is used, the fire should be thicker, from five to eight inches deep.

Peat and *coke* should be burned in a very thick fire, the former of ten to fifteen inches, the latter of fifteen to twenty inches in depth.

Wood should be burned in a very heavy fire.

Fire and Clean Out Rapidly.

When firing or cleaning out is going on, the furnace door should be kept open *only a short while,* as too much cold air cools off the grate. Besides, the boiler is liable to get damaged, as every sudden change of heat occasions a sudden contraction or expansion of the boiler-sheets, causing leaky seams. *Every unnecessary opening of the door should be dispensed with.*

Decrease the Draft when Firing.

It is a good plan to decrease the draft when firing or cleaning out, by partly closing the damper or shutting off the access of air from below the grate, in order to have only draft enough to prevent the flame from rushing out when the door is opened.

Do not Stir the Fire.

Stirring the fire should be avoided as much as possible, as it causes a waste of fuel by disturbing the combustion and by making fuel fall through the grate into the ash-pan.

Cleaning Out.

In firing with coal and coke, when so much slag is formed that the draft is suffering, the grate should be cleaned by slowly breaking up the cakes of slag with a poker and pulling them out. Rocking grates facilitate the cleaning considerably.

The furnace being large, it is best to clean half of it at a time.

The fire should be cleaned no oftener than is necessary, as cold air enters the furnace while this work is going on.

Cleaning the Grate-bars and Ash-pan.

In order to protect the grate-bars and maintain the draft, *the ash-pan and the space between the bars should be kept clean.* The spaces are cleaned from below with a claw, and the ashes in the pan are pulled out with a rake or hoe.

Never Shut the Damper while there is Fire on the Grate.

The damper must *never be entirely closed* while there is fire on the grate, as explosions dangerous to the boiler might occur in the flues. *To "bank" the fire* at night—that is, to push it back on the grate and cover it over with fresh fuel—in order to have it ready in the morning, is dangerous, as it might cause gas explosions in the flues by a blazing up of the fire, if air comes in and is mixed with the gases derived from the fuel.

Care of the Fire during Short Stops in the Work.

There being no need of extinguishing the fire while the boiler is not working—for instance, during short interruptions in the work—the damper must not be entirely closed, only shut off a little, so as to make the fire burn gently. *At stops over night, it is safest to draw the fire and rekindle a new fire in the morning.*

Dampers and Doors to Furnace and Ash-pan to be Closed when the Fire is Drawn.

The dampers and doors to the furnace and ash-pan should always be closed after the fire has been drawn, in order to keep the heat of the boiler as long as possible.

Firing into Two or More Furnaces.

When there are two or more furnaces leading to the same chimney, they should be *alternately fired,* so that, when new fuel is thrown into one, there shall be a complete combustion in the others.

Dry Fuel.

The fuel should be dry when used, as, if this is not the case, heat is lost, more than necessary being wasted; besides, when the fuel is wet, pitchy substances separate from the smoke and fasten to the sides of the tubes and flues, and so catch soot and fine ashes as they are carried along in the draft, forming a coating which hinders the conduction of heat through the metal and makes the cleaning more difficult. The fuel, therefore, should be well protected from moisture, especially when porous substances, as peat and wood, are used.

"Hard" coal, however, which generally is liable to crowd together on the grate, should be dampened before being thrown in, as it is then less liable to crowd and will burn more freely.

Loss of Heat.

In order to save fuel, all loss of heat, of course, should be carefully avoided. For this purpose, the boiler, flues and furnace should always be cleaned frequently. Blowing off steam through the safety-valves or opening the furnace doors always cause a loss of heat, and should never occur where the fire is properly cared for.

CHAPTER II.

FEED AND WATER-LINE.

Feeding.

The feeding of the boiler should be so regulated as to take place evenly and continuously and to *keep the water-line to the determined height.*

It can easily be done when a pump is used; but when feeding with injectors, it is generally more difficult unless the feeding be done frequently, a little water at a time.

As the boiler is cooled off when feeding is going on, the furnace should not be re-fired at the same time, as this also tends to cool off the boiler. When, however, continuous feed is used, *it should not be shut off when firing.*

The Water-line.

The height of the water should be kept *as constant as possible,* according to the construction of the boiler from four to eight inches above the highest parts of the furnace or flues touched by the flame or the hottest gasses. The point corresponding to the lowest water-line should always be plainly marked on the glass gauge.

False Water-line.

In boilers of high-pressure and small steam-room, it is often observed that the water surface in the glass gauge *rises,* when the throttle-valve is opened, thus showing *a higher point than the true water-line.*

Defective Feeding Apparatus.

If the water-line be decreasing although the feed apparatus is working, there are apparently *defects somewhere,* which prevent it from giving a sufficient supply of water. Such troubles are generally due to:

1. Leakage of the suction pipe.
2. Choking in the pipes;
3. The valves not being tight; or
4. Superheating of the pump, and
5. Very often *bad construction.*

When there is a test-cock on the pump, it can easily be ascertained if the pump is working properly.

Formation of Scale.

When steam is forming, the water only evaporates, and all foreign substances remain in the boiler, forming what is called "scale," being more or less hard incrustation on the sides of the boiler and tubes. Such incrustation being detrimental to the boiler and dangerous to its existence when thickly accumulated should be prevented, if possible. Some substances are successfully mixed in the water in order to neutralize the impurities and form a softer scale. Such are: pure coal-oil and sal soda, when the water contains sulphate of lime, and molasses etc., when carbonate of lime.

The Water.

The water should be as soft as can be procured, as it gives a looser scale than hard water. Where scale occurs, it should be removed frequently. In order to save fuel, *the water should be slightly heated* before feeding. Still, care should be taken not to have it too hot, as pumps and injectors do not then work well.

Arrangements for Ascertaining the Water-line.

There are used to ascertain the water-line in the boiler—

1. Gauge-cocks,
2. Glass-gauges, and
3. Floats.

The Gauge Cocks.

The *gauge-cocks* should be so arranged that the bottom-cock is a few inches below and the top-cock a few inches above the water-line, the latter thus being in connection with the steam-room. When there are three cocks, the central one is placed on the water-line. They should be opened many times daily, and the top-cock should always give *steam* and the bottom-cock *water*. They should be kept open long enough to make sure whether steam or water escapes; with a little experience this can be detected by the sound.

They should be so constructed as to admit of their being cleaned by passing an iron wire through.

The Glass Gauge.

The *glass-gauge* is so applied that its top-cock connects with the steam-room, and its bottom-cock is below the water-line. The water-line will be shown *in the centre of the tube.* It should be examined once or twice a day, and more frequently when the feed-water is very dirty. This is done by shutting the upper and opening the lower cock, which will give *water;* the latter subsequently being shut off and the former opened, *steam* will appear.

If steam and water do not appear in proper order, the cocks are choked and should be cleaned.

The bottom-cock must be opened cautiously, as the glass is liable to burst. The glass-cocks should always be perfectly tight, and as their being kept clean is of great importance, they should be so arranged as to be easily cleaned out.

Glass-gauges with a *narrow white stripe* running the whole length of the glass on the side toward the boiler are recommended as showing the water-line more clearly, especially when the water is very dirty.

The Float.

The *float* is carried on the water surface and shows the water-line by means of an index or a recorder. It should be examined a few times a day by slowly raising or lowering the balance-weight, and should the recorder show the same height after the test as before it, all is right; but if the float does not record properly, the cause is generally the packing, where the rod passes through the boiler-plate, being screwed up too tight or otherwise out of order.

Safety Plug.

Where *fusible plugs* are inserted in the crown of the furnace, these should be examined and carefully scraped clean when the boiler is being cleaned, both on the water and fire side. This being neglected, they soon cease to be of use, as so heavy sediments of soot and scale fasten to them that they are liable not to melt, even when there is no water covering the crown of the furnace.

The fusible plug should be exchanged every year, as it is useless for its purpose when old.

Alarm Whistle.

When the float is connected with an alarm whistle, it is to be borne in mind *that the whistle does not give its signal until the water has sunk below the point allowed;* the fireman, accordingly, has already neglected his duty when it is heard.

CHAPTER III.

LOW WATER AND FOAMING OR PRIMING.

Low Water

Will be found to exist—

1. By insufficient feed.
2. By foaming, or priming.
3. By leakage.

If, owing to one of these causes, the water should have sunk so low that any part of the boiler touched by the flames or the hottest gases is above the water surface, the plate in this place is rapidly heated and probably burnt, which seriously weakens its strength, thus causing danger of explosion.

Precautions when the Water is too Low.

If the water has sunk below the point allowed, it being made sure, however, that it still remains above the highest point reached by the flames, the fire should be choked by partly closing the damper, in order to leave but little draft, and by opening the furnace door, and also throwing on new fuel. Water should afterward be fed in to the necessary height, and the firing then continue as before.

If the fireman *cannot make sure how low the water has sunk*, and *if there is already danger of its having fallen below the highest point touched by the flames, the fire should be rapidly drawn.* Should any difficulties be offered to this course, or the fire be burning with a strong flame, or the crown of the furnace show signs of being red-hot, the fire should be choked with damp ashes, slag or soil or anything similar that is at hand, the furnace door and the damper should subsequently be left wide open, and the ash-pan doors be closed, in order to cool off the boiler rapidly.

Water must by no means be put in, and the steam-pressure must not be lowered by a quick exhaust of steam. If feeding be going on and if the throttle-valve be open, they should continue so, and care should always be taken that no sudden interruption in the action of the boiler should be effected. The safety-valve must not be touched, either if it be blowing off or be closed.

Not until the boiler is perfectly cool, and it has been carefully examined and found to have suffered no damage, is water to be fed in and the fire started.

Where these precautions are quickly taken, explosions will generally be prevented, but *they are inevitable* when the fireman loses his presence of mind and neglects to follow the above rules.

Foaming or Priming.

This is a violent ebullition of the water in the boiler and is generally caused by—

1. The firing or feeding not being done regularly.
2. The water-line being too high, or the steam-room too small.
3. *The evaporating* surface being too small.

4. The throttle-valve being opened too rapidly.

5. The feed-water not being pure, especially when it contains fat substances.

6. The boiler not being clean.

Some authorities on steam make a distinction between priming and foaming referring the former to causes 1 to 4 and the latter to 5 and 6, but such a distinction is of little importance.

When foaming occurs, the water is carried with the steam and enters the cylinders, when the steam is used for an engine, impeding the motion of the piston, causing it to move irregularly. If too much water enters the cylinder, there is danger of knocking a head out.

It can become so excessive as to cause a scarcity of water in the boiler.

Foaming or priming may be perceived by a sudden rising and falling of the water-line in the glass-gauge, and in steam-engines by a cracking noise in the cylinders. It can be overcome, or at least decreased, *by partially closing the throttle-valve, rapidly feeding in water and opening the furnace door.*

CHAPTER IV.

STEAM PRESSURE.

Steam Pressure.

This should never be allowed to exceed the highest limit. If the steam-gauge shows so rapid an increase of pressure as to give danger of exceeding the highest limit, water should be immediately fed in and the damper partially closed, in order to diminish the effect of the fire. If the pressure should exceed what *'s allowed,* the furnace doors should be opened and the ash-pan doors shut and the feeding apparatus should afterward be started; but if the water has fallen so low that there is any danger from that cause, then the feed must *not* be started.

The Steam Gauge.

The steam-gauge should be so applied as to be easily seen by the fireman, and there should be a plain mark on it showing the highest pressure allowed in the boiler. Where spring gauges are used, as is now generally the case, they should be frequently compared with a quicksilver or metal control gauge. A quicksilver gauge with float being used, it should be frequently examined by slowly pulling the string, to make sure that the float moves freely in the tube. See that the finger points to zero when there is no pressure in the boiler. A two-way cock should be applied for closing the connection between the steam-gauge and the boiler, and at the same time to let in air to the steam-gauge; this cock must be used a few times daily, in order to see that the steam-gauge finger points to zero when steam-pressure is cut off, and it should always be kept clean.

Safety Valves.

The safety-valve must be loaded in such a manner as to blow off sufficient steam that the highest pressure limit in the boiler shall not be exceeded, and *this load must never be increased.* In some cases it is a good plan to have this weight so arranged as to be inaccessible to the fireman.

The valve is examined by slowly raising it a little, and, when let down, it should close perfectly tight.

If it does not close tight, turn it on its seat until it fits, or, where its construction does not permit this proceeding, raise it slowly a few times and let it down again. This not being sufficient, grind it to fit when the boiler is cool.

The valve must never be opened by a sudden knock or pull, and it is essential that the load must by no means be increased *to make the valve tight.*

The fireman is cautioned against hanging his dinner-pail, his shovel, or his boots to dry on the safety valve lever, as the writer has seen done.

When cleaning the boiler, all parts of the safety-valve should be examined to make sure that they are in order, and that the valve can rise from its seat to the proper height.

CHAPTER V.

CLEANING AND BLOWING OUT.

Cleaning the Boiler.

Dirt is removed from the boiler by washing and blowing out partially or totally.

When the boiler is to be cleaned, *the water should not be blown out by steam-pressure ;* it should remain in the boiler while it is cooling and should be let out through the blow-off cock and the mud holes. All mud plugs and man and hand hole covers are to be removed, the scale is to be loosened by light knocks with a hammer and the boiler to be washed inside with clean water. For this purpose water with pressure from a hose-pump or water-works is conveniently used. The scale should be removed as soon as possible after the water has been let out, as there is considerable difficulty in detaching it, if allowed to dry and harden.

All pipes and cocks should be examined, and all parts, inside and outside, most carefully looked after. The blow-off cock should be taken apart and oiled, and it should be seen that it is tight and works easily. The feed-pipes particularly are to be examined that they be not choked by sediment, which frequently occurs where there is a bend and at the inlet to the boiler

Scale and sediment are generally deposited where the heat is strongest, and the plate around the furnace and flues should therefore be carefully cleaned; they are most dangerous in these places, as preventing, when grown too thick, the water from touching the plate, which is liable to turn red-hot and lose its necessary strength. The furnace, flues, and ash-pan should also be cleaned of soot and ashes.

To Examine the State of the Boiler.

When cleaning inside, it should be seen that there are no corrosions of importance in the sheet-seams and the cement packings of the manholes and pipe-flanges, these places being chiefly liable to corrosion; and also that the stays and braces are in good order.

All defects should, of course, be remedied as soon as possible.

The outside of the boiler is to be well protected *from moisture,* and if the boiler is set up in brickwork, it should be seen to that there is no dampness in it, as serious oxidations might be occasioned.

Before screwing up the manhole and other covers, care should be taken that nothing is left in the boiler.

Blowing Out Partially.

It is *blown out partially* by opening the bottom blow-off while pressure is on the boiler, and letting a portion of the water out, when the sediment, having sunk to the bottom, is blown out with it. The best result is obtained if the water has been in rest for some time, thus giving the sediment time to settle.

When a *surface cock* is attached to the boiler, it may be used instead of the bottom-cock, when blowing out partially, and it is used with more advantage when the feed-water contains salts.

The Best Time to Blow Out.

Boilers in shops and manufactories not working at night should be blown out partially *in the morning*, shortly after the fire is started. It is usually blown out so that the water-line falls one or one and a half inches; the corresponding quantity of water should, of course, be fed in the evening before, in order to have the average water-line after blowing out. The rest at noon is also a good opportunity for blowing out.

It is due to the purity of the feed-water as to how often such blowing out should be done; this being very dirty, it should be blown out every morning and noon.

Blowing Out Totally.

All the water should be blown out only as a means of necessity, a more complete change of water being necessary than can be attained by a partial blow out. It is performed in the same way, but should never be done under a higher steam-pressure than fifteen or twenty pounds. The fire should be extinguished before blowing out. Some water should always be left in the boiler, as its cooling off might take place so irregularly as to cause leaks. The doors and dampers are to be closed in order to facilitate a gradual cooling.

It can be told from the sound of the running water when the blow-off cock is to be closed, sufficient water being left when it flows unevenly and carries steam. To prevent the forming of a vacuum in the boiler when the steam is condensed, the gauge-cocks should be opened after blowing, unless the boiler is provided with an *automatic air-valve* which lets in the air when the pressure has fallen to a certain limit.

Refilling the Boiler.

When *cold water* is used, the boiler should be refilled very cautiously, and *not until it is perfectly cool. When hot water is used, the boiler should be hot,* which is to be preferred, there being no such liability to sudden and irregular changes of temperature as when using cold water.

CHAPTER VI.

GENERAL DIRECTIONS.

How to Prevent Accidents.

In order to prevent accidents the fireman must never neglect—

1. To watch most carefully that there may never be too little water in the boiler.
2. To see that the steam-pressure must never exceed the highest limit.
3. To clean the boiler frequently and thoroughly.
4. To note that all the apparatus and other parts of the boiler are always in complete working order.

Repairs.

All defects of the boiler and its parts must be repaired as soon as possible, should they seem to be of ever so little importance, and leaks and other untightness should especially not be allowed to continue long.

Never neglect to report to your superiors what you suspect to be wrong about your boiler, or you will be responsible for the consequences. Many times boilers explode, and whether the fireman survives the catastrophe or not, he is charged with neglect, when the cause probably was a defective boiler.

The Care of the Boiler when Not in Use.

When the boiler is not to be used for some time, either the water should be let out and the boiler carefully cleaned and wiped and means be taken to protect it from moisture, or it should be pumped quite full of water. The furnace and flues should be swept and cleaned; ashes and slag to be raked out and carried away. It may be here mentioned that damp ashes form a very strong corrosive, and will seriously injure any plates with which they come in contact, if allowed to stand any length of time.

Finished iron surfaces should be covered with a composition of tallow and white lead, in order to prevent rust.

Testing the Boiler.

A repair of any importance having been made, and whenever a man of experience thinks it necessary (at any rate every five years), *the boiler should be tested* by pumping in water. When under test, the boiler is generally exposed to an effective pressure of twice the highest allowed when it is in use, but the working pressure should not be exceeded by more than seventy-five to one hundred pounds.

Trimming and Cleaning Outside.

The cocks, valves and all brass or copper pipes should always be kept clean and bright, and ashes, slag or water must never be allowed to gather around the grate or ash-pan. The floor, ceiling and walls of the boiler-room are also to be frequently cleaned in order to afford safety against fire.

Every good fireman will take pains to have everything look neat and clean around his boiler.

SUMMARY OF RULES.

Before starting the fire take note—

1. That there is sufficient water in the boiler;
2. That the glass-gauge or float shows the true water-line;
3. That the grate and tubes are clean, and that the grate-bars are in their right positions;
4. That the upper gauge-cock is open to let out the air from the boiler;
5. That the feed apparatus is in order;
6. That the dampers and doors move easily;
7. That all other parts of the boiler are in good condition.

After starting the fire and steam-pressure, take note—

1. That the joints and packings are tight;
2. That the cocks and valves move freely.

Let the fire develop slowly in order to heat the boiler gradually, rapid heating being detrimental to the life of the boiler.

Fire evenly and regularly. After every firing, for a short while, keep the air-holes open or the furnace door ajar. *Put in the fuel in small quantities and frequently, and keep the grate continually covered with a fire of equal thickness.* Cover over bare spots with fresh fuel. Never put in coal of larger size than your fist.

Fire rapidly, and don't keep the furnace door open longer than necessary. Regulate the depth of the fire by the quality of the fuel, and so regulate the draft as to make the fire burn with a bright flame, equally all over the grate. Prevent as much as possible dark smoke issuing from the chimney.

Don't stir the fire except when necessary.

Clean the fire when needed. Never leave slag and ashes on the floor before the furnace.

Keep the openings between the grate-bars well cleaned, and never let too many ashes gather in the ash-pan.

Never shut the damper entirely while there is fire on the grate. At short stops in the work, shut off the damper a little so as to keep the fire burning slowly. The day's work over, it is best to draw the fire and clean the grate.

See that the fuel is dry, when used.

Regulate the feed as evenly as possible, so as to keep the water-line constant.

Use the purest water to be obtained.

The feed apparatus working badly is generally due to—

1. Leakage of the suction pipe ;
2. Choking in the pipes ;
3. The valves not being tight or being checked in some way ;
4. The feed-water being too hot ; or
5. The pump being heated.

If there is a test-cock on the pump, examine if the pump is working properly.

Note that the water-line does not vary, and particularly see that it never falls too low.

If the water has fallen below the point allowed, there being no danger, however, of too low water, choke the fire by partially closing the damper, put in new fuel, and open the furnace door. Subsequently start the feed quickly to obtain the proper height of water.

If there is danger from the water having fallen too low, draw the fire rapidly. Should there be any difficulties to this proceeding or the fire be burning with a strong flame, choke the fire with damp ashes, slag, soil, or anything similar that is at hand; then keep the furnace doors and dampers wide open and close the ash-pan doors. *The steam-pressure must by no means be decreased by feeding in water or suddenly blowing off steam.* If the feed apparatus is working or the throttle-valve be open, let them remain as they are for a short time, and when you close them, do so very cautiously. Don't touch the safety-valve, either if it be open or closed, and always *avoid as much as possible all sudden interruptions of the action of the boiler.*

To overcome foaming, close the throttle-valve, feed in water rapidly, and open the furnace doors.

Turn the gauge-cocks open a few times daily.

Examine the glass-gauge once or twice a day that it shows the true water-line.

When a float is used, examine frequently that it moves freely.

Keep the steam-pressure even, and never allow it to rise above the limit.

Should the pressure exceed the limit, open the furnace doors and start the feed apparatus.

Take notice that the steam-gauge is in order.

The safety-valve should be so loaded as to blow off sufficient steam to prevent the steam-pressure from increasing above the limit. The determined load must never be increased.

Examine daily that the safety-valve moves freely and is tight.

Always open the throttle-valve slowly.

Clean the boiler inside frequently and carefully; for this purpose let the water out, and don't start the cleaning *until the boiler has had time to cool.* If, however, there is not time to do so, let in cold water to mix with the hot in the boiler, in order to cool it the sooner. Be careful, however, that cold water does not come in contact with the hot plate.

Examine and clean all cocks, valves and pipes, and look to all joints and packings, while cleaning the boiler, *and look carefully that there be no important corrosions inside.*

Such corrosions generally occur in the seams and around joints.

Blow off partially once or twice a day according as the water is more or less pure. Close the blow-off when the water has sunk one to one and a half inches.

Protect the outside of the boiler from all moisture.

Repair as soon as possible all defects on the boiler or its parts, especially leaks, etc.

Always take care that the boiler and its parts are in good order, and keep all finished surfaces bright.

Never let water remain on the floor about the boiler. Clean the boiler-room frequently, and take care that everything there is kept neat and in good order.

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